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Solar Coronal Structure Study

Final Contract Report

Contract NASW-96005

Period of Performance
11 September, 1996 through 10 September, 1997

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1 Introduction

The subject of this investigation is the study the physics of the solar corona through the analysis of the EUV and UV data produced by two flights (12 May 1992 and 25 April 1994) of the Lockheed Solar Plasma Diagnostics Experiment (SPDE) sounding rocket payload, in combination with Yohkoh and groundbased data. These joint datasets are useful for understanding the physical state of the solar atmosphere from the photosphere to the corona at the time of the rocket flights. Each rocket flight produced both spectral and imaging data. Highlights of this initial year of the contract included compilation, scaling and co-alignment of image sets, substantial progress on the Bright Point study, initial work on the Active Region and Large Scale Structure studies, DRSG slit-aspect determination work and calibration activities. One paper was presented at the 1997 Annual Meeting of the AAS/SPD in Bozeman, Montana. An initial set of calibrated spectra were placed into the public domain via the World Wide Web. Three Quarterly Progress Reports have been submitted; progress for the fourth quarter of the contract is summarized in this Final Contract Report.

The intent of the investigation is to compare the physics of small- and medium-scale structure with that of large-scale structures with weak fields. A study has been identified in each size domain. At the smallest scale is a Bright Point Study, led by Dr. N. Nitta. An Active Region Study, led by Dr. J. Saba with the assistance of Dr. J. Schmelz, concentrates on medium-scale structures. Coronal Holes and Filaments are the topics of the studies at large scales. Since each of these studies depends on the quantitative analysis of images and / or spectra, the calibration of the rocket data forms an important element of the work. Of equal importance is the slit-aspect solution, which determines the correspondence between locations along the spectrograph slit and points on the solar disk. These tasks are being carried out by Dr. W. A. Brown.

2 X-Ray Bright Point Study

Nitta began this study with a systematic analysis of the long exposure full-disk images taken with the Yohkoh SXT instrument around the time of the second flight of the Solar Plasma Diagnostics Experiment (SPDE) rocket payload (25 April, 1994). This work, done during the first quarter of the contract year, demonstrated that bright points were more easily detected in the long exposures than in the usual SXT full-disk movie. About 50 bright points were identified that could be seen in both the SXT and in the Fe XII images recorded by the Normal Incidence X-ray Imager (NIXI) that was included in the rocket payload. The work continued in the second quarter of the contract year with a careful co-alignment of the NIXI Fe IX and Fe XII images with those from the Yohkoh SXT and a magnetogram from Kitt Peak (Figure 1). A preliminary comparison of the (uncalibrated) intensities showed a good correlation between the two NIXI images, but a weaker one with the higher-temperature structures seen by SXT. A good correspondence was found between the locations of bright points at all three wavelengths and bi-poles in the magnetogram, as one would expect.

During the third quarter, Nitta incorporated high-resolution magnetograms and He I λ10830 spectroheliograms from Kitt Peak and H-Lyman α images from the rocket data into the study. The study of the latter did not support the findings of Kankelborg, Walker and Hoover (1997, ApJ, Submitted) that X-ray bright points show double footpoints in their H-Lyman α images.

3 Active Region Study

Work on this problem began in the first quarter of the contract year with a review by Nitta of all SXT partial frame images from 25 April, 1994. Dr. J. Schmelz of the University of Memphis joined the investigation to work on the spectroscopic diagnostics. A subcontract was issued to support her effort.

During the second quarter, Schmelz installed the Chianti data base and software and began studying the temperature and densidy dependence of spectrum line-pairs that are available in the rocket spectra. The digitized (but uncalibrated) spectra were also transferred to the University of Memphis.

Nitta received synthesized microwave images from T. Bastian of the VLA during the third quarter. These were co-aligned with the X-ray, C IV, white-light and magnetograph images in preparation for further study incorporating the UV/EUV spectra. The results are shown in Figure 2. M. Bruner renewed a previous study of data sets from the SMM UVSP experiment to better understand the temporal behavior of active-region structures seen in C IV.

Activities during the fourth quarter included participation in the AAS/SPD meeting in Bozeman, Montana. Bruner presented a paper on the spatial distribution

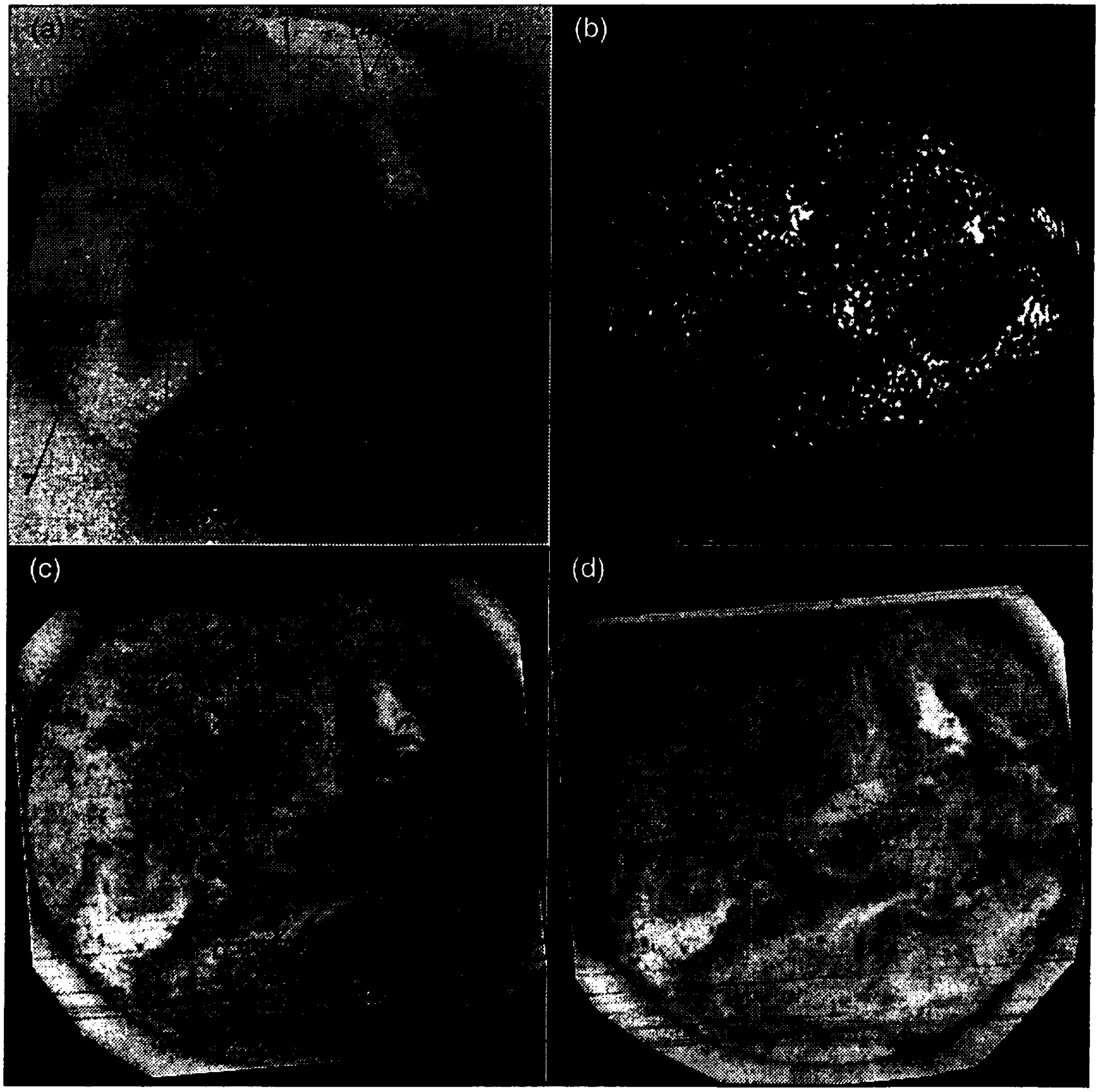

Figure 1: Full disk images from the 25 April 1994 dataset: (a) Yohkoh SXT image; (b) Kitt Peak magnetogram; (c) NIXI 171 Å image; (d) NIXI 195 Å image.

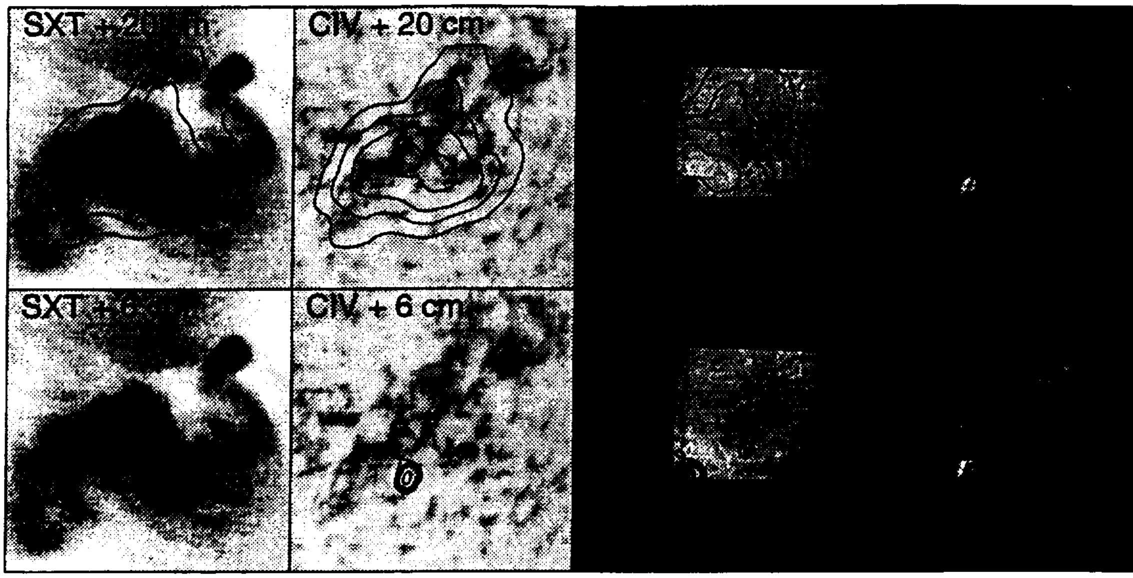

Figure 2: Co-aligned image set from the 1992 SPDE flight campaign. Microwave intensities at 20 cm and 6 cm are shown by the contour lines.

and the temporal evolution of active region loop structures seen in the C IV line. An Abstract of the paper is included as Appendix A of this report. The Co-Investigators also took advantage of the meeting to confer on the status of the investigation.

4 Large Scale Structure Study

It was originally intended that much of this study would be carried out during the second and third years of this investigation. However, some relevant work has been done this year. During the first quarter, Nitta's review of the long-exposure full-disk images from Yohkoh SXT confirmed that coronal holes were more clearly identified than in the de-saturated SXT movies. We also found that some coronal holes seen by SXT appear to be more extended than in the NIXI and He I λ10830 images. It may be that portions of these regions contains trapped plasma that is too cool to be seen by SXT. This could raise concerns about previous coronal hole studies based on SXT results.

During the third quarter, Nitta compiled and co-aligned a set of images containing a large filament that was visible in H-α and He I λ10830. He plans to attempt a re-construction of the three-dimensional topology of the region by studying its evolution in Yohkoh SXT images and in the Nobeyama 17 GHz radioheliograph data.

5 Calibration Activities

W. A. Brown, the project scientist for the rocket flights, led the calibration and attitude determination work, which has extended throughout the entire year of this contract. Brown is a Lockheed retiree and has been supported under a subcontract. His work included updating line lists, work on the rocket aspect solution, reviewing densitometry results, interpolating spectra and images onto a common scale, converting selected density observations to exposure values, and normalizing the results to radiance values. A selected list of line intensities has been released for unrestricted use by interested scientists. The data are located on the World Wide Web at URL http://macinnes.space.lockheed.com.

Nitta has also participated in the calibration work with the goal of incorporating Brown's results into IDL code that can be used to perform the conversions. This work was still in progress at the end of the contract year.

A Abstracts

Scale Height Temperatures and Dynamics in Post Flare and Active Region Loops

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An analysis of C IV movies of the solar limb have revealed two distinctly different classes of loop structures. Those of the first class appear to be ejecta, show proper motions of the order of 100 - 200 km/sec, follow trajectories along magnetic field lines, and have an uneven intensity distribution along their lengths. The second class is quasi-stationary, and the intensity obeys an apparent scale-height law (i.e. an exponential decrease of intensity with height above the surface). Analysis of the scale heights under a straightforward set of assumptions allows us to determine a temperature parameter that is substantially higher than the ionization temperature. Structures of the second class do not show proper motions in the movies, but appear to form in place, suggesting that they result from the cooling of hotter plasmas.